

A Guide to Hindcasting in the HEFS

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**National Weather Service
Office of Hydrologic Development**

Change History

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1. Overview

Streamflow hindcasting with the HEFS differs from the ESP hindcasting conducted by the RFCs. In particular, the MEFP is calibrated with precipitation and temperature hindcasts from several Numerical Weather Prediction (NWP) models, as well as climatological forcing. These forcing ensembles are inputs to a hydrologic processor, which generates the streamflow ensemble hindcasts. The streamflow hindcasts are then bias-corrected with a hydrologic post-processor, EnsPost. The output from MEFP, the hydrologic processor, and EnsPost need to be exported for verification purpose (e.g., via the Ensemble Verification System).

Using two operational basins at MARFC (WALN6DEL and CNNN6DEL in the UpperDelaware forecast group, where WALN6DEL is a headwater basin and CNNN6DEL is its downstream basin) as an example, this document describes how to update the operational standalone (SA) configuration for hindcasting purpose. It assumes that MEFP and EnsPost have already been configured in this operational SA (refer to the MEFP Configuration Guide: Forecast Components and the EnsPost Configuration Guide). Particularly, this document describes the configuration of exporting the results of MEFP, the hydrologic processor, and EnsPost. In addition, this document outlines the steps involved in running the hindcasting with the MEFP, the hydrologic processor, and EnsPost.

It is worth noting that this document serves as a “cookbook” on how to set up and conduct HEFS streamflow hindcasting in CHPS and export the corresponding results for verification. This document will not provide scientific guidance on hindcasting, such as the hindcasting scenarios needed to answer particular questions about forecast quality or the necessary length of hindcasts for verification purposes. For more information on the scientific guidance of hindcasting, the reader is referred to a companion document Verification of Medium-range Forecasts from the NWS Hydrologic Ensemble Forecast Service (HEFS) with Forcing Inputs from the Frozen Version of NCEP’s Global Forecast System (GFS).

1.1 Notation

- Text to be entered as a command line is displayed in *italics*.
- Text in a file name or directory name, text to be entered into an ASCII text file (including xml files), and the file name of any reference document are denoted in this font.

2. Configuration Change

This document assumes you will run CHPS in an SA and all the configuration files are contained in a single directory (e.g., marfc_sa.hindcast) referred to as <test_root> hereinafter. This document also assumes that both MEFP and EnsPost are already configured in the SA. This section describes 1) the configuration change to the hydrologic processor so that it can be run in the hindcasting mode; and 2) the configuration to export the results of MEFP, the hydrologic processor, and EnsPost.

2.1 Configuration of Exporting MEFP Hindcasts

Configuration of the MEFP workflow and its associated forecast module instances has been detailed in MEFP Configuration Guide: Forecast Components. As such, this document only describes how to create an export workflow (MEFP_Export.xml) and an export module instance for each location (XX_MEFP_precip_Export.xml, XX_MEFP_temp_Export.xml) to export the MEFP hindcasts to data files. Figure 1 shows the (xml) files that need to be created or modified to export MEFP hindcasts, as well as their proper locations in the <test_root> file structure.

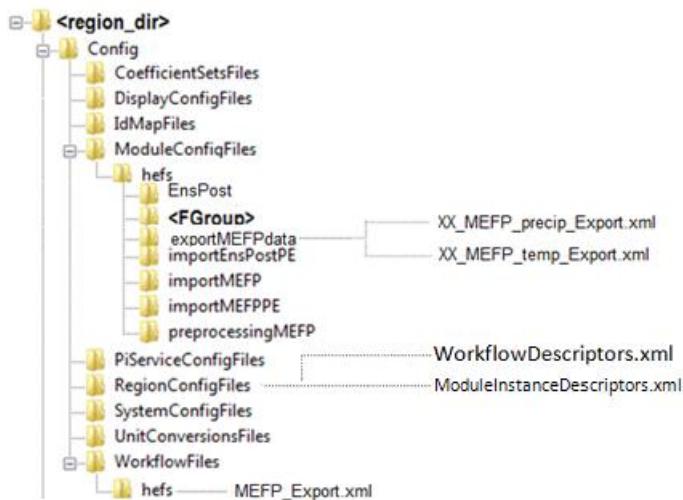


Figure 1: Configuration files for exporting MEFP hindcasts

The procedure of creating an export workflow and two corresponding export module instances to export the MEFP hindcasts is described below.

- `cd <test_root>/Config/WorkflowFiles/hefs`
- `nedit MEFP_Export.xml`

In the file opened, add the content in the table below (using WALN6DEL as an example):

Standard Location:<test_root>/Config/WorkflowFiles/hefs/

Content of MEFP_Export.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<workflow xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/workflow.xsd" version="1.1">
  <activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>WALN6DEL_MEFP_precip_Export</moduleInstanceId>
    <ensemble>
      <ensembleId>MEFP</ensembleId>
      <runInLoop>false</runInLoop>
    </ensemble>
  </activity>
  <activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>WALN6DEL_MEFP_temp_Export</moduleInstanceId>
    <ensemble>
      <ensembleId>MEFP</ensembleId>
      <runInLoop>false</runInLoop>
    </ensemble>
  </activity>
</workflow>
```

- cd <test_root>/Config/ModuleConfigFiles/hefs/exportMEFPdata
- nedit XX_MEFP_precip_Export.xml

Add the following content (using WALN6DEL as an example; for CNNN6DEL, update all “WALN6DEL” to be “CNNN6DEL”) to the file opened to export the precipitation hindcasts:

Standard Location:<test_root>/Config/ModuleConfigFiles/hefs/exportMEFPdata

Content of WALN6DEL_MEFP_precip_Export.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<timeSeriesExportRun xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/timeSeriesExportRun.xsd">
  <export>
    <general>
      <exportTypeStandard>pi 1.5</exportTypeStandard>
      <folder>$EXPORT_FOLDER$</folder>
      <exportFileName>
        <name>_WALN6DEL_MEFP_precip.</name>
        <prefix>
          <timeZeroFormattingString>yyyyMMddHH</timeZeroFormattingString>
        </prefix>
        <suffix>
          <simpleString>xml</simpleString>
        </suffix>
      </exportFileName>
      <idMapId>IdExportMEFPPE</idMapId>
    <unitConversionsId>importEnglishUnits</unitConversionsId>
    <exportMissingValue>-999</exportMissingValue>
```

```

        </general>
        <timeSeriesSet>
            <moduleInstanceId>FGroup_MEFP_FMAP_Forecast</moduleInstanceId>
            <valueType>scalar</valueType>
            <parameterId>FMAP</parameterId>
            <locationId>WALN6DEL</locationId>
            <timeSeriesType>external forecasting</timeSeriesType>
            <timeStep unit="hour" multiplier="6"/>
            <relativeViewPeriod unit="hour" start="0" startOverrulable="false" end="7920"
endOverrulable="false"/>
            <readWriteMode>read only</readWriteMode>
            <ensembleId>MEFP</ensembleId>
            <ensembleMemberIndexRange start='1961' end='1997'/>
        </timeSeriesSet>
    </export>
</timeSeriesExportRun>

```

- `cd <test_root>/Config/ModuleConfigFiles/hefs/exportMEFPdata`
- `nedit XX_MEFP_temp_Export.xml`

Add the following content (using WALN6DEL as an example; for CNNN6DEL, update all “WALN6DEL” to be “CNNN6DEL”) to the file opened to export the temperature hindcasts:

Standard Location:<test_root>/Config/ModuleConfigFiles/hefs/exportMEFPdata

Content of WALN6DEL_MEFP_temp_Export.xml

```

<?xml version="1.0" encoding="UTF-8"?>
<timeSeriesExportRun xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/timeSeriesExportRun.xsd">
    <export>
        <general>
            <exportTypeStandard>pi 1.5</exportTypeStandard>
            <folder>$EXPORT_FOLDER$</folder>
            <exportFileName>
                <name>_WALN6DEL_MEFP_temp.</name>
                <prefix>
                    <timeZeroFormattingString>yyyyMMddHH</timeZeroFormattingString>
                </prefix>
                <suffix>
                    <simpleString>xml</simpleString>
                </suffix>
            </exportFileName>
            <idMapId>IdExportMEFPPE</idMapId>
            <unitConversionsId>importEnglishUnits</unitConversionsId>
            <exportMissingValue>-999</exportMissingValue>
        </general>
        <timeSeriesSet>
            <moduleInstanceId> MEFP_FMATT_Forecast</moduleInstanceId>
            <valueType>scalar</valueType>
            <parameterId>FMATT</parameterId>
            <locationId>WALN6DEL</locationId>
            <timeSeriesType>external forecasting</timeSeriesType>
            <timeStep unit="hour" multiplier="6"/>
            <relativeViewPeriod unit="hour" start="0" startOverrulable="false" end="7920"
endOverrulable="false"/>

```

```

<readWriteMode>read only</readWriteMode>
<ensembleId>MEFP</ensembleId>
<ensembleMemberIndexRange start='1961' end='1998' />
</timeSeriesSet>
</export>
</timeSeriesExportRun>

```

Now register the workflow and module instances created:

- *cd <test_root>/Config/RegionConfigFiles/*
- *nedit WorkflowDescriptors.xml*
- add the following lines to the file opened:

```

< workflowDescriptor id="MEFP_Export" name="MEFP Export" forecast="false" visible="false" allowApprove="false"
autoApprove="false">
    <description>MEFP Results Export</description>
</workflowDescriptor>

```

- *nedit ModuleInstanceDescriptors.xml*
- add the following lines to the file opened:

```

<moduleInstanceDescriptor id="WALN6DEL_MEFP_precip_Export">
    <moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>
<moduleInstanceDescriptor id="WALN6DEL_MEFP_temp_Export">
    <moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>

```

Note: The “relativeViewPeriod” in the export module instances (namely, XX_MEFP_precip_Export.xml, XX_MEFP_precip_Export.xml) defines the period of data to export. The current instances export data from T0 hours up to 7920 hours (330 days).

2.2 Configuration of the Hydrologic Processor

Configuring the hydrologic processor involves configuring the carryover workflow (and its associated configuration files to generate warm states) and the forecast workflow for the test locations. This section provides descriptions on how to conduct these configuration changes.

2.2.1 Create new location set for the test locations

This is to create a location set exclusively containing the test locations (WALN6DEL and CNNN6DEL in this case) by modifying the file LocationSets.xml. This location set will be applied in subsequent configuration.

- *cd <test_root>/Config/RegionConfigFiles/*
- *nedit LocationSets.xml*
- add the following part to the file

```

<locationSet id="Catchments_HEFS">
    <locationId>WALN6DEL</locationId>
    <locationId>CNNN6DEL</locationId>
</locationSet>

```

2.2.2 Create/update forecast workflow and relevant configuration files

Configuring the forecast workflow and its associated configuration files includes:

- 1) pre-processing the imported MEFP hindcasts with the workflow UpperDelaware_PreProcessing_Forecast.xml and its associated merge module instances;
- 2) creating the export workflow HEFS_Flow_Export.xml its associated export module instances;
- 3) creating the parent forecast workflow HEFS_Flow_Forecast.xml to run MEFP, hydrologic processor and export resulting MEFP hindcasts and streamflow hindcasts to data files.

2.2.2.1 Pre-process MEFP hindcasts

This step prepares the MEFP hindcasts for ingest into the hydrologic models. This can be done by running the pre-processing workflow UpperDelaware_PreProcessing_Forecast.xml. This workflow need to be updated by adding the module instance to produce MAPE ensembles:

- *cd <test_root>/Config/WorkflowFiles/UpperDelaware/*
- *nedit UpperDelaware_PreProcessing_Forecast.xml*

In the file opened, add the content:

```

<activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>SetTimes_ESP_Forecast</moduleInstanceId>
</activity>
<activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>UpperDelaware_SampleESP_Forecast</moduleInstanceId>
</activity>

```

In the module instance UpperDelaware_SampleESP_Forecast (under Config/ModuleConfigFiles/preprocessing_esp/), change the following content

```

<variable>
    <variableId>MAPE_Historic</variableId>
    <timeSeriesSet>
        <moduleInstanceId>ImportSHEF</moduleInstanceId>
        <valueType>scalar</valueType>
        <parameterId>MAPE</parameterId>
        <locationSetId>Meteo_UpperDelaware</locationSetId>
        <timeSeriesType>external historical</timeSeriesType>
        <timeStep id="12Z"/>
    </timeSeriesSet>
</variable>

```

```

        <relativeViewPeriod unit="day" start="-36500" end="0"/>
        <readWriteMode>read only</readWriteMode>
    </timeSeriesSet>
</variable>
```

to be

```

<variable>
    <variableId>MAPE_Historic</variableId>
    <timeSeriesSet>
        <moduleInstanceId>ImportSHEF</moduleInstanceId>
        <valueType>scalar</valueType>
        <parameterId>MAPE</parameterId>
        <locationSetId>Meteo_UpperDelaware</locationSetId>
        <timeSeriesType>external historical</timeSeriesType>
        <timeStep id="12Z"/>
        <relativeViewPeriod unit="day" start="-36500" end="0"/>
        <readWriteMode>read complete forecast</readWriteMode>
    </timeSeriesSet>
</variable>
```

This change is necessary to for UpperDelaware_SampleESP_Forecast to produce different MAPE traces.

For the three module instances (UpperDelaware_MergeMAT_Forecast, UpperDelaware_MergeMAPX_Forecast, UpperDelaware_MergeMAPE_Forecast) , add the following content:

```

<ensemble>
    <ensembleId>MEFP</ensembleId>
    <runInLoop>true</runInLoop>
</ensemble>
```

The updated module instance looks like, taking UpperDelaware_MergeMAT_Forecast for an example:

```

<activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>UpperDelaware_MergeMAT_Forecast</moduleInstanceId>
    <ensemble>
        <ensembleId>MEFP</ensembleId>
        <runInLoop>true</runInLoop>
    </ensemble>
</activity>
```

Two merge module instances of this workflow should also be updated as follows:

- *cd <test_root>/Config/ModuleConfigFiless/preprocessing/*
- *nedit UpperDelaware_MergeMAT_Forecast.xml*

In the file opened, add the content:

```

<variable>
    <variableId>FMAT_MEFP</variableId>
    <timeSeriesSet>
        <moduleInstanceId>MEFP_FMAT_Forecast</moduleInstanceId>
        <valueType>scalar</valueType>
```

```

<parameterId>FMAT</parameterId>
<locationSetId>Catchments_HEFS_FGroup</locationSetId>
<timeSeriesType>external forecasting</timeSeriesType>
<timeStep unit="hour" multiplier="6"/>
<relativeViewPeriod unit="hour" start="-240" startOverrulable="true" end="0" endOverrulable="true"/>
<readWriteMode>read only</readWriteMode>
<ensembleId>MEFP</ensembleId>
</timeSeriesSet>
</variable>

```

In <transformation id="MergeMAT">, comment out all inputVariable and add the following inputVariable:

```

<inputVariable>
    <variableId>FMAT_MEFP</variableId>
</inputVariable>

```

Update UpperDelaware_MergeMAPX_Forecast.xml in the same way:

- cd <test_root>/Config/WorkflowFiles/UpperDelaware/
- nedit UpperDelaware_MergeMAPX_Forecast.xml

In the file opened, add the content:

```

<variable>
    <variableId>FMAP_MEFP</variableId>
    <timeSeriesSet>
        <moduleInstanceId>FGroup_MEFP_FMAP_Forecast</moduleInstanceId>
        <valueType>scalar</valueType>
        <parameterId>FMAP</parameterId>
        <locationSetId>Catchments_HEFS_FGroup</locationSetId>
        <timeSeriesType>external forecasting</timeSeriesType>
        <timeStep unit="hour" multiplier="6"/>
        <relativeViewPeriod unit="hour" start="-240" startOverrulable="true" end="0" endOverrulable="true"/>
        <readWriteMode>read only</readWriteMode>
        <ensembleId>MEFP</ensembleId>
    </timeSeriesSet>
</variable>

```

In <transformation id="MergeMAP">, comment out all inputVariable and add the following inputVariable:

```

<inputVariable>
    <variableId>FMAP_MEFP</variableId>
</inputVariable>

```

Note: In these two files updated, there is no need to merge historical data (MAP/MAT) into MEFP hindcasts.

2.2.2.2 Export streamflow hindcasts

This step creates an export workflow and two corresponding export module instances to export the streamflow hindcasts generated by the hydrologic processor.

- `cd <test_root>/Config/WorkflowFiles/hefs`
- `nedit HEFS_Flow_Export.xml`

In the file opened, add the content in the table below:

Standard Location:<test_root>/Config/WorkflowFiles/hefs/

Content of HEFS_Flow_Export.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<workflow xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/workflow.xsd" version="1.1">
    <activity>
        <runIndependent>true</runIndependent>
        <moduleInstanceId>WALN6DEL_HEFS_Export</moduleInstanceId>
    </activity>
    <activity>
        <runIndependent>true</runIndependent>
        <moduleInstanceId>CNNN6DEL_HEFS_Export</moduleInstanceId>
    </activity>
</workflow>
```

- `cd <test_root>/Config/ModuleConfigFiles/hefs/Flowhindcasts`
- `nedit XX_HEFS_Export.xml`

Add the following content (using WALN6DEL as an example; for CNNN6DEL, update all “WALN6DEL” to be “CNNN6DEL”) to the file opened:

Standard Location:<test_root>/Config/ModuleConfigFiles/hefs/Flowhindcasts

Content of WALN6DEL_HEFS_Export.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<timeSeriesExportRun xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/timeSeriesExportRun.xsd">
    <export>
        <general>
            <exportTypeStandard>pi 1.5</exportTypeStandard>
            <folder>$EXPORT_FOLDER$</folder>
            <exportFileName>
                <name>_WALN6DEL_HEFS.</name>
                <prefix>
                    <timeZeroFormattingString>yyyyMMddHH</timeZeroFormattingString>
                </prefix>
                <suffix>
                    <simpleString>xml</simpleString>
                </suffix>
            </exportFileName>
            <idMapId>IdExportMEFPPE</idMapId>
        </general>
        <timeSeriesSet>
            <moduleInstanceId>ADDSUB_WALN6DEL_ADD.BFQ_Forecast</moduleInstanceId>
            <valueType>scalar</valueType>
            <parameterId>SQIN</parameterId>
            <locationId>WALN6TOT</locationId>
            <timeSeriesType>simulated forecasting</timeSeriesType>
        </timeSeriesSet>
    </export>
</timeSeriesExportRun>
```

```

<timeStep unit="hour" multiplier="6"/>
<relativeViewPeriod unit="hour" start="0" startOverrulable="false" end="7920"
endOverrulable="false"/>
<readWriteMode>read only</readWriteMode>
<ensembleId>MEFP</ensembleId>
<ensembleMemberIndexRange start='1961' end='1997'/>
</timeSeriesSet>
</export>
</timeSeriesExportRun>
```

Now register the workflow and module instances created:

- *cd <test_root>/Config/RegionConfigFiles/*
- *nedit WorkflowDescriptors.xml*
- add the following lines to the file opened:

```

<workflowDescriptor id="HEFS_Flow_Export" name="HEFS Export" forecast="false" visible="true" allowApprove="false"
autoApprove="false">
<description>HEFS Export</description>
</workflowDescriptor>
```

- *nedit ModuleInstanceDescriptors.xml*
- add the following lines to the file opened:

```

<moduleInstanceDescriptor id="WALN6DEL_HEFS_Export">
<description>Export HEFS Streamflow Hindcasts WALN6DEL</description>
<moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>
<moduleInstanceDescriptor id="CNNN6DEL_HEFS_Export">
<description>Export HEFS Streamflow Hindcasts CNNN6DEL</description>
<moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>
```

Note: The “relativeViewPeriod” in the export module instances (namely, Export_HEFS_Hindcast_XX.xml) defines the period of data to export. The current instances export data from T0 up to 330 days.

2.2.2.3 Create forecast workflow

This step creates the parent workflow HEFS_Flow_Forecast.xml. This workflow

- 1) calls the MEFP forecast workflow (MEFP_Forecast.xml) and export workflow (MEFP_Export.xml) to generate and export MEFP hindcasts respectively;
- 2) executes the pre-processing workflow UpperDelaware_PreProcessing_Forecast.xml to merge historical observations into MEFP hindcasts imports;
- 3) runs hydrologic models (via workflows XX_Flow_Forecast.xml) to produce streamflow hindcasts; and
- 4) exports the hindcasts produced through the export workflow HEFS_Flow_Export.xml.

- *cd <test_root>/Config/WorkflowFiles/hefs/*
- *nedit HEFS_Forecast.xml*

Add the following content to the file opened:

Standard Location:<test_root>/Config/WorkflowFiles/hefs/

Content of HEFS_Forecast.xml

```

<?xml version="1.0" encoding="UTF-8"?>
<workflow xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/workflow.xsd" version="1.1">
    <activity>
        <runIndependent>true</runIndependent>
        <workflowId>MEFP_Forecast</workflowId>
    </activity>
    <activity>
        <runIndependent>true</runIndependent>
        <workflowId>MEFP_Export</workflowId>
    </activity>
    <activity>
        <runIndependent>false</runIndependent>
        <workflowId>UpperDelaware_PreProcessing_Forecast</workflowId>
    </activity>
    <activity>
        <runIndependent>false</runIndependent>
        <workflowId>WALN6DEL_Flow_Forecast</workflowId>
        <ensemble>
            <ensembleId>MEFP</ensembleId>
            <ensembleMemberIndexRange start='1961' end='1997'/>
            <runInLoop>true</runInLoop>
        </ensemble>
    </activity>
    <activity>
        <runIndependent>false</runIndependent>
        <workflowId>CNNN6DEL_Flow_Forecast</workflowId>
        <ensemble>
            <ensembleId>MEFP</ensembleId>
            <ensembleMemberIndexRange start='1961' end='1997'/>
            <runInLoop>true</runInLoop>
        </ensemble>
    </activity>
    <activity>
        <runIndependent>false</runIndependent>
        <workflowId>HEFS_Flow_Export</workflowId>
    </activity>
</workflow>

```

And register the workflow:

- *cd <test_root>/Config/RegionConfigFiles/*
- *nedit WorkflowDescriptors.xml*
- add the following lines to the file:

```

<workflowDescriptor id="HEFS_Forecast" name="HEFS_Forecast" forecast="true" visible="true" allowApprove="true"
autoApprove="true">
```

```

<description>HEFS Flow Forecast using updated states</description>
<cardinalTimeStep id="12Z"/>
<stateSelection>
    <warmState>
        <stateSearchPeriod start="-6" end="0" unit="day"/>
    </warmState>
</stateSelection>
<runExpiryTime unit="day" multiplier="100"/>
</workflowDescriptor>

```

Note: the end date of the search period of warm states should be defined as zero. Otherwise, the forecast workflow will not be able to find the correct warm states to start. The warm states search period can be defined when registering the forecast workflow, as highlighted in bold in file WorkflowDescriptors.xml above.

2.3 Configuration of Exporting EnsPost-processed Hindcasts

Configuration of the EnsPost workflow and its associated forecast module instances has been detailed in EnsPost Configuration Guide. This document describes how to create an export workflow (EnsPost_Flow_Export.xml) and an export module instance for each location (XX_ENSPOST_Export.xml) to export the EnsPost-processed streamflow hindcasts to data files. Figure 2 shows the (xml) files that need to be created or modified.

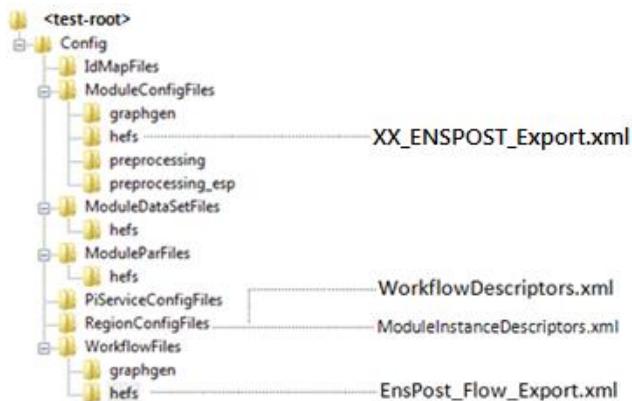


Figure 2. Configuration files for exporting EnsPost-process streamflow hindcasts

2.3.1 Create EnsPost export workflow and module instances

This step involves creating an export module instance for each test location to export the data produced by the EnsPost, and then creating a workflow to execute the module instances.

First, create the export module instances:

- `cd <test_root>/Config/ModuleConfigFiles/hefs/EnsPost`
- `nedit WALN6DEL_ENSPOST_Export.xml`

Add the following content to the file opened:

Standard Location: <test_root>/Config/ModuleConfigFiles/hefs/

Content of WALN6DEL_ENSPOST_Export.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<timeSeriesExportRun xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/timeSeriesExportRun.xsd">
    <export>
        <general>
            <exportTypeStandard>pi 1.5</exportTypeStandard>
            <folder>$EXPORT_FOLDER$</folder>
            <exportFileName>
                <name>_WALN6DEL_EnsPost.</name>
                <prefix>
                    <timeZeroFormattingString>yyyyMMddHH</timeZeroFormattingString>
                </prefix>
                <suffix>
                    <simpleString>xml</simpleString>
                </suffix>
            </exportFileName>
            <idMapId>IdExportMEFPMAP</idMapId>
            <unitConversionsId>importEnglishUnits</unitConversionsId>
                <exportMissingValue>-999</exportMissingValue>
            </general>
        <timeSeriesSet>
            <moduleId>WALN6DEL_ENSPOST_Forecast</moduleId>
            <valueType>scalar</valueType>
            <parameterId>SQIN</parameterId>
            <locationId>WALN6DEL</locationId>
            <timeSeriesType>simulated forecasting</timeSeriesType>
            <timeStep unit="hour" multiplier="6"/>
                <relativeViewPeriod unit="hour" start="0" end="7920"/>
            <readWriteMode>read only</readWriteMode>
            <ensembleId>HEFSENPOST</ensembleId>
                <ensembleMemberIndexRange start="1961" end="1997"/>
        </timeSeriesSet>
    </export>
</timeSeriesExportRun>
```

- *cp WALN6DEL_ENSPOST_Export.xml CNNN6DEL_ENSPOST_Export.xml*
- *nedit CNNN6DEL_ENSPOST_Export.xml*
- change all WALN6DEL to be CNNN6DEL

Next, register these two module instances:

- *cd <test_root>/Config/RegionConfigFiles/*
- *nedit ModuleInstanceDescriptors.xml*
- add the following lines to the file:

```
<moduleInstanceDescriptor id=" WNLN6DEL_ENSPOST_Export">
    <description>Export EnsPost-processed Hindcasts WNLN6DEL</description>
    <moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>
```

```

<moduleInstanceDescriptor id="CNNN6DEL_ENSPOST_Export">
  <description>Export EnsPost-processed Hindcasts CNNN6DEL</description>
  <moduleId>TimeSeriesExportRun</moduleId>
</moduleInstanceDescriptor>

```

Then create the export workflow:

- *cd <test_run>/Config/WorkflowFiles/hefs/*
- *nedit EnsPost_Flow_Export.xml*

Add the following content to the file opened:

Standard Location: <test_root>/Config/WorkflowFiles/hefs/

Content of EnsPost_Flow_Export.xml

```

<?xml version="1.0" encoding="UTF-8"?>
<workflow xmlns="http://www.wldelft.nl/fews" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews http://chps1/schemas/workflow.xsd" version="1.1">
  <activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>WALN6DEL_ENSPOST_Export</moduleInstanceId>
  </activity>
  <activity>
    <runIndependent>true</runIndependent>
    <moduleInstanceId>CNNN6DEL_ENSPOST_Export</moduleInstanceId>
  </activity>
</workflow>

```

Last, register the workflow:

- *cd <test_run>/Config/RegionConfigFiles/*
- *nedit WorkflowDescriptors.xml*
- add the following lines to the file:

```

<workflowDescriptor id="EnsPost_Flow_Export" name="EnsPost Export" forecast="false" visible="false" allowApprove="false"
autoApprove="false">
  <description>EnsPost Export</description>
</workflowDescriptor>

```

Note 1) if the user is interested in only exporting the data for selected locations, then the user will only need to include the export module instances for those locations as the activities in this export workflow. 2) The “relativeViewPeriod” in the export module instances (namely , Export_EnsPost_XX.xml) defines the period of data to export. The current instances export data from T0 up to 330 days.

2.3.2 Add EnsPost forecast and export files to the parent workflow

This involves adding XX_ENSPOST_Forecast.xml and EnsPost_Flow_Export.xml to the parent workflow HEFS_Forecast.xml:

- `cd <test_run>/Config/WorkflowFiles/hefs/`
- `nedit HEFS_Forecast.xml`
- add the following content to the file:

```

<activity>
  <runIndependent>false</runIndependent>
  <moduleInstanceId>WALN6DEL_ENSPOST_Forecast</moduleInstanceId>
</activity>
<activity>
  <runIndependent>false</runIndependent>
  <moduleInstanceId>CNNN6DEL_ENSPOST_Forecast</moduleInstanceId>
</activity>
<activity>
  <runIndependent>false</runIndependent>
  <workflowId>EnsPost_Flow_Export</workflowId>
</activity>

```

3. Example Run

As mentioned in Section 2.2, the MEFP-based HEFS hindcasting run includes two major steps. The first step is to produce the warm states of the hydrologic models for the hindcasting runs. The second step is to generate the streamflow hindcasts by running a single workflow. In the meantime, the EnsPost is run to post-process and export the generated streamflow hindcasts. Those steps are shown below.

3.1 Produce Initial Model States

The warm states of the hydrologic models are produced by running the hydrologic models with historical observed forcing. These data, which include MAP and MAT, need to be imported via the import workflow (e.g., ‘Import Scalars’). If MAPE is specified as input for the rainfall-runoff model (i.e., SAC-SMA and API models), it has to be imported as well. For MARFC, MAPE data can also be imported via workflow Import Scalars.

After importing the observed data into the CHPS database, the workflow (UpperDelaware_Flow_UpdateStates.xml) can be run to produce warm states. Let’s assume we want to generate warm states over a 20-year period (01-01-1979 12:00:00 ~ 01-01-1999 12:00:00). After selecting the workflow in the Manual Forecast Display, it is necessary to select appropriate module instances to run. In this case, three modules need to be selected, as shown in Figure 3.

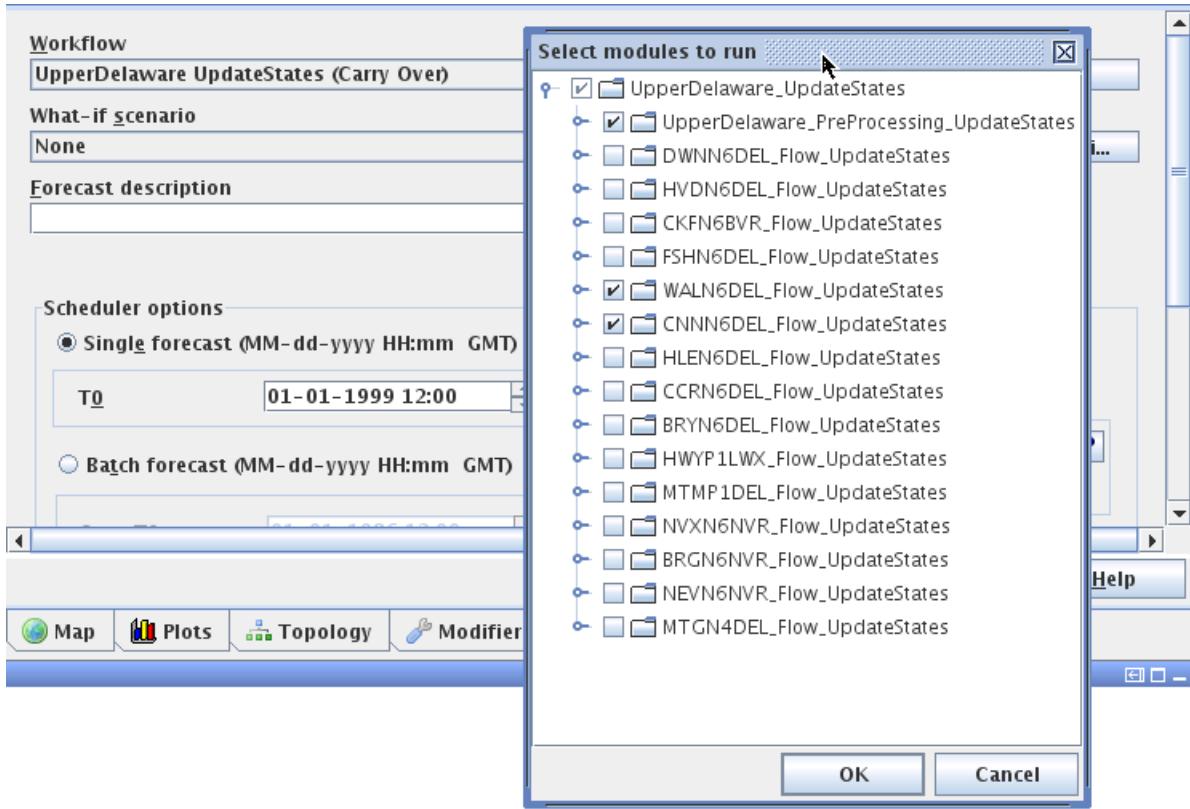


Figure 3. Select appropriate module instances to run

Next, an appropriate warm-up period (e.g., longer than one year) should be defined to allow the models to arrive at an appropriate state at the start (01-01-1979 12:00:00) of the hindcasting period. This can be set up in the FEWS manual forecast display as shown in Figure 4. In this example, a 2-year warm-up period is used. The update states workflow is run from 01-01-1977 to the end of the hindcasting period (01-01-1999 12:00:00). Note the “Approve” box should be checked so that the model states from this spin-up run will be saved in the database for later use. There is no need to change the forecast length in the manual forecast display.

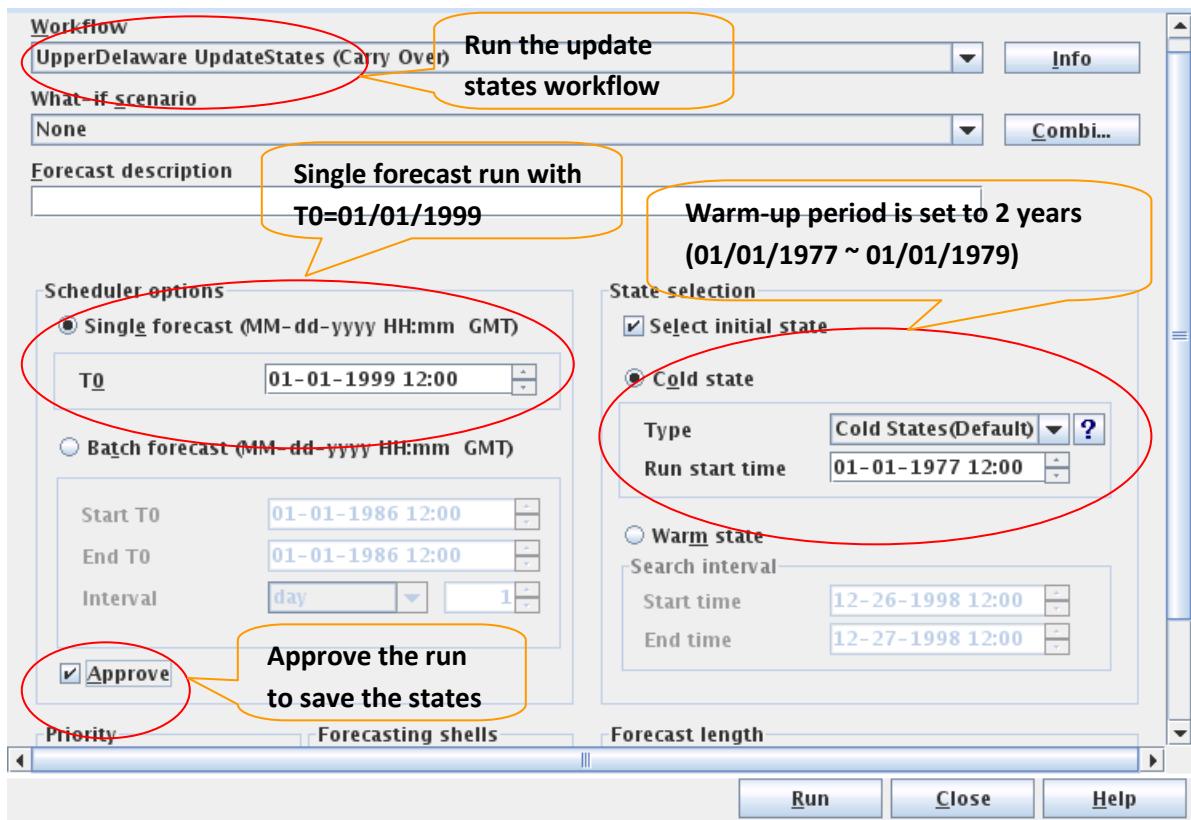


Figure 4. Update states run to generate warm states

3.2 Generate Streamflow Hindcasts and EnsPost-processed Data

Running the parent workflow (HEFS_Forecast.xml) in batch mode will produce MEFP hindcasts, streamflow hindcasts, and call EnsPost to post-process these streamflow hindcasts. The detailed instructions are as follows: in Manual Forecast display (refer to Figure 5):

- Select the workflow “HEFS_Forecast”
- Check “Batch forecast” in Scheduler options; specify Start T0 to be “01-01-1986 12:00:00”, End T0 to be “01-05-1986 12:00:00”, with “1 day” as the interval.
- Define “330 days” as the forecast length
- Press “Run”
- The xml format data (Streamflow hindcasts and EnsPost-processed data) files defined in WALN6DEL_HEFS_Export.xml, CNNN6DEL_HEFS_Export.xml, WALN6DEL_ENSPOST_Export.xml and CNNN6DEL_ENSPOST_Export.xml will be exported to directory <test_root>/Export/

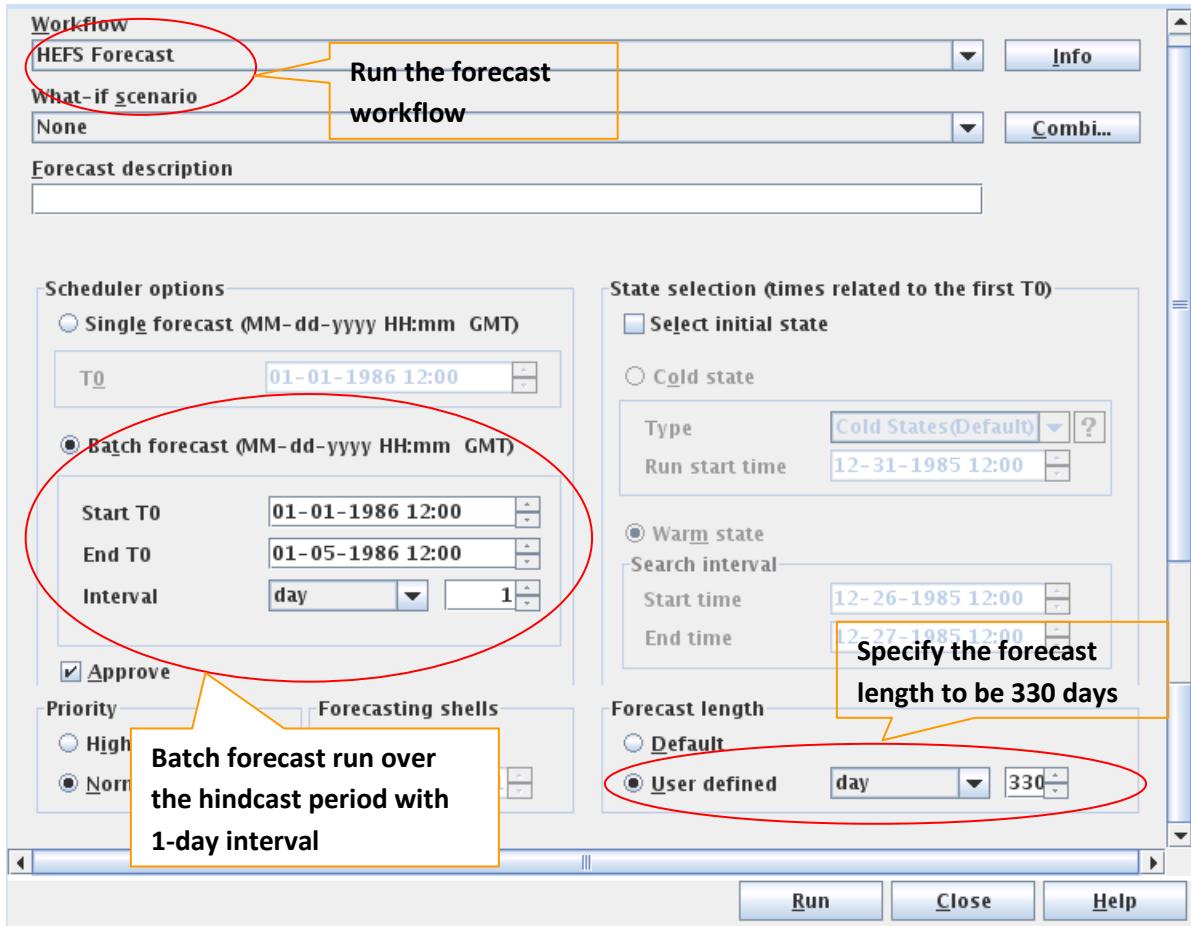


Figure 5. Run the forecast workflow in a batch mode to generate the hindcasts

The MEFP hindcasts, streamflow hindcasts, and EnsPost-processed hindcasts can also be visualized via CHPS Database Viewer following the instructions below: inside the Logs Panel of CHPS display:

- Press “F12”, and then select “J”. This will open CHPS Database Viewer.
 - a) Select a T0 that you are interested in viewing (e.g., 01-05-1986 12:00:00; refer to Figure 6a); all time series corresponding to this T0 will show up, as shown in Figure 6a.
 - b) Select a module instance of interest (e.g., UpperDelaware_MergeMAPX_Forecast and UpperDelaware_MergeMAT_Forecast which produce MEFP hindcasts for the hydrologic processor); select the time series corresponding to these two module instances for ensemble ID 1961, as shown in Figure 6a.

Figure 6a: Select time series to plot

- c) Once the time series of interest has been selected, right click and select Show time series dialog F10 (refer to Figure 6a). The selected time series will be plotted, as illustrated in Figure 6b.

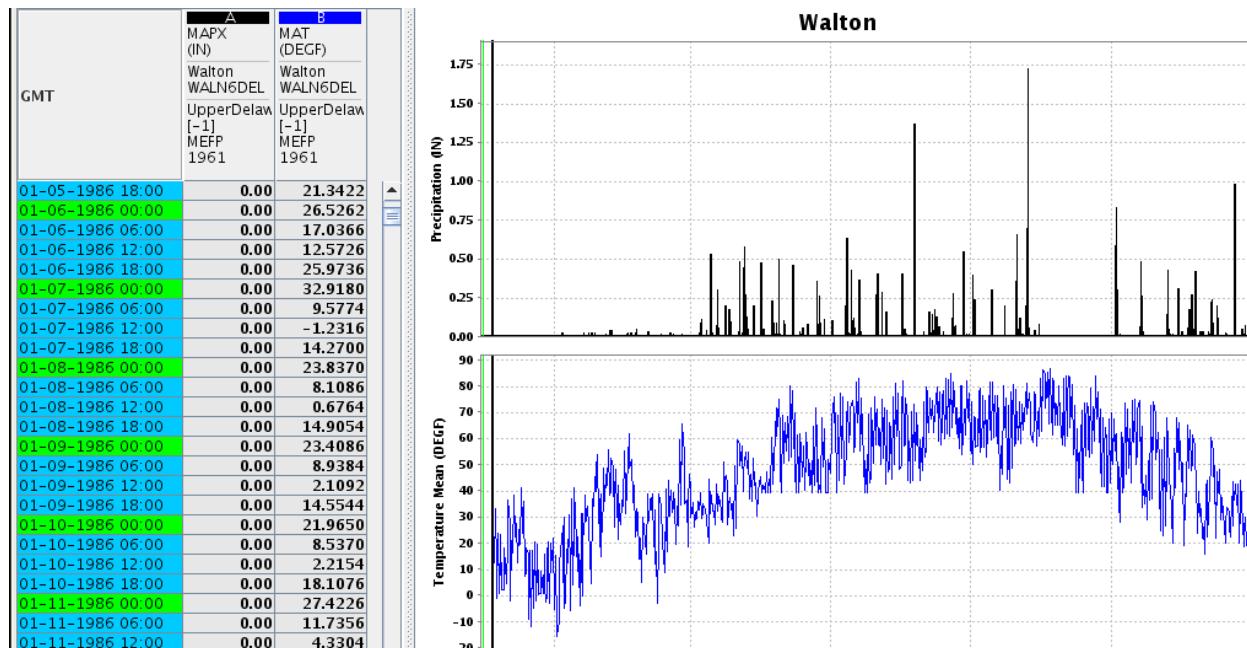


Figure 6b. MEFP hindcasts for WALN6DEL (Ensemble ID: 1961)

- d) Repeat steps b) and c) for other module instances of interest (e.g., ADD.SUB_WALN6DEL_ADD.BFQ_Forecast for streamflow hindcasts produced for WALN6DEL (Figure 6c); WALN6DEL_ENSPOST_Forecast, for EnsPost-processed hindcasts for WALN6DEL (Figure 6d)).

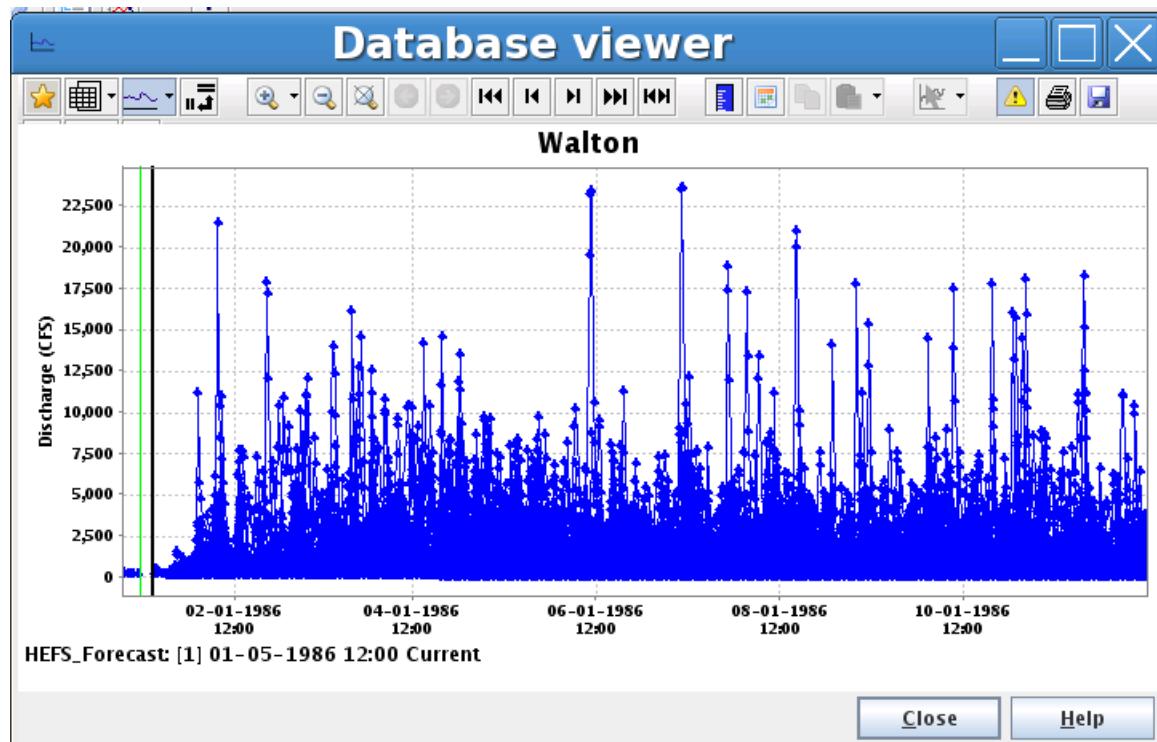


Figure 6c: Plot of streamflow hindcasts at WALN66DEL

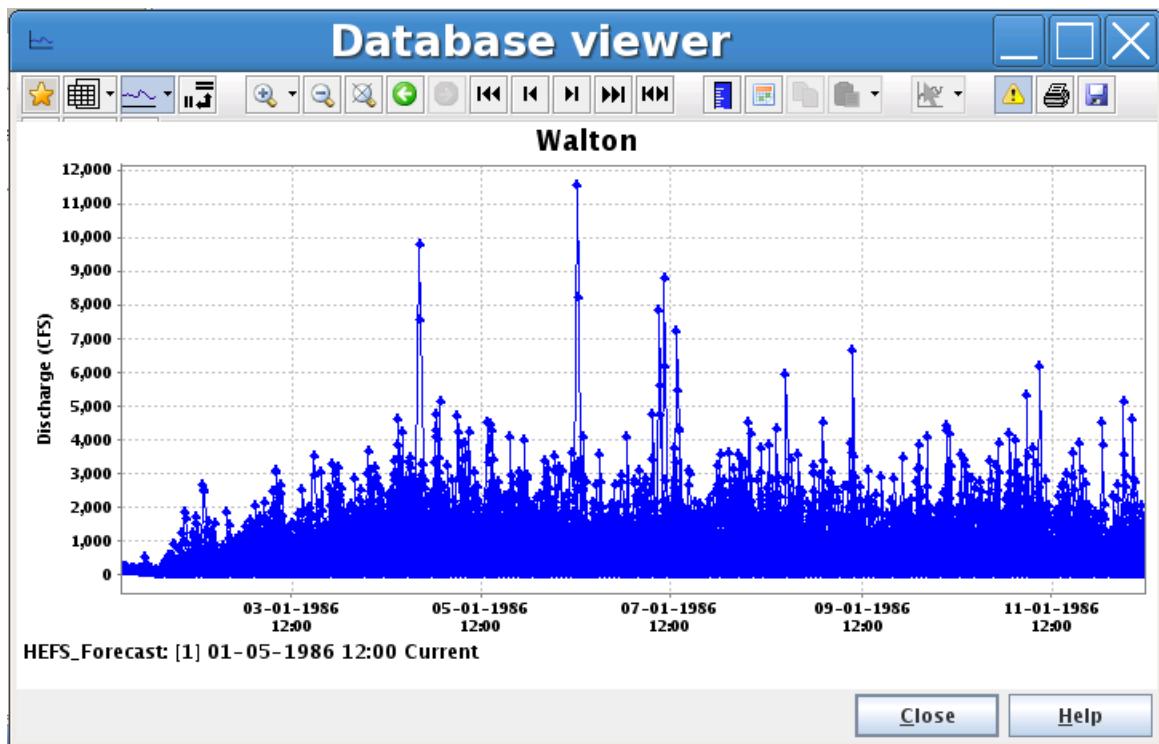


Figure 6d: EnsPost-processed streamflow hindcasts at WALN66DEL

- e) Repeat steps a) through d) for other T0s of interest.

4. References

MEFP Configuration Guide: Forecast Components, HEFS 0.3.2 Release, OHD, April 2013

EnsPost Configuration Guide, HEFS 0.3.2 Release, OHD, April 2013

Verification of Medium-range Forecasts from the NWS Hydrologic Ensemble Forecast Service (HEFS) with Forcing Inputs from the Frozen Version of NCEP's Global Forecast System (GFS), Technical Report, OHD, March 2013